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TONSEA RECYCLE CENTER WEB-APP DEVELOPMENT USING PXP METHOD

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Abstract: Waste bank management in North Minahasa, particularly at the Tonsea Recycle Center (TRC), still relies on manual transaction recording which causes data inefficiency, limited transparency, and difficulties for users in monitoring their recycling activities. These limitations reduce community participation in waste sorting and recycling programs. This study presents the development of a web-based application for the Tonsea Recycle Center (TRC) aimed at improving operational efficiency, data transparency, and user engagement through a point-based reward mechanism. The development process adopted the Personal Extreme Programming (PXP) methodology, encompassing stages of requirement analysis, system design, implementation, testing, deployment, and maintenance. The application was developed using HTML, CSS, Python, Django, and SQLite, and includes features such as user authentication, transaction management, a reward point system, and an administrative dashboard[1]. Functional testing, user acceptance testing (UAT), and security testing were conducted to evaluate the system. The results demonstrate that the application effectively overcomes the limitations of the manual system by automating transaction records, enabling real-time data access, and enhancing transparency. Functional testing showed that all system features successfully passed 100% of the test cases, while User Acceptance Testing indicated that the majority of users rated the system interface as easy to use and responsive. This research concludes that the TRC web application significantly contributes to improving waste bank operations and community involvement. Future enhancements are suggested, including integration with digital payment systems, AI-based waste classification, and mobile application development to increase system accessibility and utility.

Keywords: Waste Bank Management, Web Application, Personal Extreme Programming (PXP), Waste Recycling, Reward System, Django, Community Participation, Transparency, Digital Waste Management

1. INTRODUCING

Waste management continues to be a pressing environmental issue in Indonesia. It significantly contributes to global greenhouse gas (GHG) emissions, accounting for 3.2% or approximately 1,580 billion tonnes of CO_2 annually[2]. In the capital city of North Sulawesi, waste generation reaches about 650 tons per day, resulting in overcapacity at waste disposal sites such as the Sumompo landfill[3]. These conditions emphasize the urgent need for sustainable and effective waste management solutions that address both environmental and societal challenges.

Waste banks have been introduced as an effective initiative to raise public awareness and promote community involvement in recycling and waste separation[4]. However, the current waste bank systems

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largely operate manually and lack integration with digital platforms. This leads to inefficiencies in transaction recording, data management, and public participation. The Tonsea Recycle Center (TRC), a waste bank located in North Minahasa, aims to improve community participation through a reward-based system where users deposit recyclable waste and earn points that can be redeemed for cash or goods. Despite this promising mechanism, TRC faces numerous operational challenges including manual data handling, low awareness about proper waste sorting, limited space, and logistical inefficiencies. These obstacles hinder TRC's ability to expand and operate effectively.

North Minahasa is one of Indonesia's Super Priority Tourism Destinations, with the Likupang area being a key focus of tourism development. Sustainable tourism requires solid waste management systems, including the establishment of waste banks, to preserve environmental quality and support community-based tourism or "Desa Wisata."[5]. In Airmadidi District, which serves as the administrative center of North Minahasa, population density and poor waste logistics management further complicate the situation[6]. Implementing a circular economy approach—where waste is treated as a valuable resource to be reused or repurposed—can enhance sustainability and economic resilience. This concept, applied through the Rumah Sampah Digital initiative in Kolongan Village[7], demonstrates that community-based waste management can reduce pollution, provide organic compost for agriculture, generate income, and promote eco-conscious behavior[8].

The development of a web-based application specifically tailored for TRC is proposed in this study to modernize and digitize its waste management processes. Several studies have explored digital waste management systems. Ardani et al. [9] developed the Trash-Mate Android application to support waste bank transactions through a mobile platform. Meanwhile, Al Amin et al. [10] designed the E-Trash web-based system to manage waste bank data and improve transaction recording. Although these systems improved efficiency, they lack flexibility for local waste bank operations and do not implement an agile development approach such as Personal Extreme Programming (PXP). Therefore, this research proposes the development of a customized web-based system for Tonsea Recycle Center using the PXP methodology.

This study introduces a web-based application designed using the Personal Extreme Programming (PXP) methodology, which is a lightweight, iterative approach derived from Extreme Programming (XP), suitable for individual developers [11]. PXP allows developers to continuously plan, design, code, test, and refine their systems, making it adaptable to user feedback and real-world challenges. The system is built using HTML, CSS, Python, Django, and SQLite to ensure performance, flexibility, and ease of maintenance[12].

The focus of this research is the development of a web-based platform that enhances the operational capacity of TRC, improves transaction recording accuracy, increases transparency, and engages the local community in waste sorting and recycling practices. The platform targets users domiciled in North Minahasa and excludes enforcement mechanisms for non-compliance. Key features of the system include user authentication, digital transaction recording, a points-based reward mechanism, and an admin dashboard for efficient management.

Through the implementation of this digital platform, the research aims to provide practical benefits to multiple stakeholders. For the academic and developer community, it serves as a case study in applying agile development methodologies like PXP. For the community, it promotes sustainable waste management behavior. For waste bank administrators, it streamlines operations and improves data

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reliability. Overall, this solution aspires to support a more transparent, efficient, and participatory waste management ecosystem in North Minahasa.

2. RESEARCH METHODOLOGY

2.1. Data Collection Method

The methodology consists of the following main phases, which are adapted from the RAD framework:

1. Interviews

Semi-structured interviews were conducted with key stakeholders to gather detailed requirements and feedback.

2. Observation

Field observations documented the current manual processes of waste collection, recording, and reward distribution.

3. Document Analysis

Analysis of past operational records and relevant literature provided additional context and validation for system requirements.

2.2. Research Stages

The stages of this research follow a linear and structured process to ensure that the objectives are clearly defined, the methodology is appropriately applied, and the outcomes are accurately documented. The main stages of the research are as follows:

1. Start

This phase marks the initiation of the research process, beginning with preliminary exploration and preparation.

2. Observation

In this stage, the core problem of waste management inefficiency at Tonsea Recycle Center was identified through observations and interviews. The scope and significance of the issue were clearly stated.

3. PXP Methodology Application

The research adopted the Personal Extreme Programming (PXP) method, which includes planning, designing, coding, testing, deploying, and maintaining the web application. This methodology was chosen for its suitability for solo development and iterative nature.

4. Results and Discussion

After implementation, the functionality and impact of the developed system were evaluated. The findings were analyzed and compared with initial expectations to assess the system's effectiveness.

5. Report Preparation

The results of the research were compiled into a structured thesis document, which includes background, literature review, methodology, results, and conclusion.

6. End

The research process concludes after documentation and revision are complete, signaling the finalization.

2.3. Developments Method

The Personal Extreme Programming (PXP) methodology was adopted to develop the web-based application for the Tonsea Recycle Center. PXP emphasizes simplicity, adaptability, and iterative development, making it suitable for a solo researcher.

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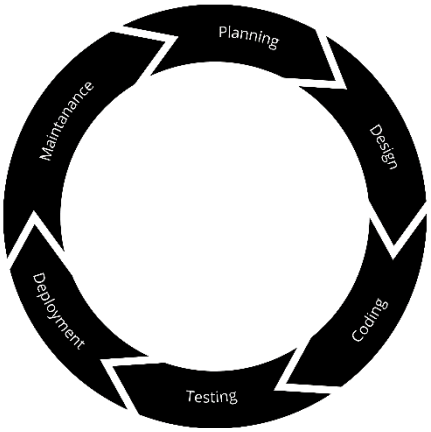

Figure 1. PxP Developments Method

The development of the web-based application followed the Personal Extreme Programming (PXP) methodology, beginning with the Planning Phase, where system requirements were gathered through interviews and observations, then translated into user stories and prioritized based on critical functionalities such as waste transaction recording, balance checking, and data management[11]. In the Design Phase, a simple and scalable system architecture was created, supported by wireframe prototypes to visualize the user interface. The Coding Phase involved independent development to ensure full control over implementation, with incremental builds tested regularly to maintain stability and prevent major bugs. During the Testing Phase, continuous manual testing was conducted to verify feature functionality, followed by User Acceptance Testing (UAT) to validate the system in real-world conditions with feedback from stakeholders. The Deployment Phase started with a pilot rollout, allowing gradual expansion toward full-scale implementation. Lastly, in the Maintenance and Iteration Phase, ongoing feedback was collected to refine features, resolve issues, and apply updates based on user input and operational data, ensuring continuous system improvement.

3. RESULT AND DISCUSSIONS

3.1. Planning Phase

The planning phase of the Tonsea Recycle Center (TRC) web application was conducted using the Personal Extreme Programming (PXP) methodology, which emphasizes adaptability and iterative development. This stage focused on identifying system requirements, translating them into user stories, and prioritizing core features that directly impact user experience.

3.1.1. User Stories Development

To ensure the system met real-world user needs, requirements were gathered through direct interviews and field observations involving key stakeholders, including members and administrators of Tonsea Recycle Center (TRC). The insights obtained were then formulated into user stories, which defined the core functionalities that needed to be developed.

The following table summarizes the key findings from these sessions:

Table 1. Summary of Interview Results and User Needs

No	Stakeholder	Interview Question	Identified Need / Insight	User Story

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1	Member	How do you currently record your waste transactions?	Manual recording is inefficient; users want a digital system.	"As a member, I want to record my waste deposits digitally so that I can earn points for recycling."
2	Member	How do you check your points balance?	Difficult to check unless asking admins directly.	"As a member, I want to check my point balance so that I can track my points."
3	Member	Would you like to keep a copy of your waste transactions?	Users want downloadable transaction records to track their contributions.	"As a member, I want to download my transaction history in Excel format so I can track my waste."
4	Member	How do you currently update your personal info?	Users have difficulty updating contact info and prefer doing it themselves.	"As a member, I want to easily update my profile info like phone number and address without admin help."
5	Admin	What is the biggest challenge in your current workflow?	Managing and validating waste transactions manually takes too much time.	"As an admin, I want to manage waste transactions so that I can verify and assign points accordingly."
6	Admin	How do you manage user accounts at the moment?	Admins need better tools for searching and managing users effectively.	"As an admin, I want to manage user data more efficiently with search and filter tools."
7	Admin	Is transaction history easy to navigate?	Both admin struggle to find specific transactions due to lack of filtering.	"As a admin, I want to filter transaction history by date or waste type for easier navigation."

These user stories served as the foundation for planning and design decisions in the development process. By prioritizing these needs, the system was built to solve the exact problems faced by its target users.

3.1.1. Feature Prioritization

Given the solo development nature of the project, prioritization was essential to maintain efficiency and ensure that the most crucial features were developed first. The selection criteria were based on:

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1. Core functionality: Features that enable basic system operations, such as transaction recording and user management.
2. User impact: Features that directly benefit users, particularly members, by allowing them to track their waste deposits and rewards.
3. System usability: Ensuring the system is easy to use, with intuitive navigation and clear workflows.

The top three prioritized features were:

1. Points Redemption: This feature allows members to submit details of their waste deposits while enabling admins to verify and assign points.
2. Check Balance: Members can view their accumulated points, promoting transparency and encouraging continued participation in the waste management program.
3. Waste Data Management: Admins can monitor, update, and analyze waste deposit records to ensure efficient system operation.
4. Transaction History Export: Users wanted to download their transaction records in Excel format.
5. Profile Management: Users needed an easier way to update their personal data like phone number and address.
6. Manage Users: Admins required better tools to edit, deactivate, and search user accounts efficiently.
7. History Filters: A filter feature was added to help users and admins search transactions by date or waste type.

By focusing on these core features first, the system ensured smooth operation and addressed the fundamental requirements of both members and administrators.

3.2. Design Phase

In this phase, the system was designed with a focus on simplicity, scalability, and usability to meet immediate needs while allowing for future improvements. The design process involved structuring the system architecture, selecting appropriate technologies, and creating prototypes to visualize the user interface and system workflows.

3.2.1. Simple and Scalable System Design

The system architecture was structured to ensure seamless interaction between the frontend, backend, and database. The decision to use Django for the backend and HTML/CSS for the frontend was based on their flexibility, security, and ease of development. SQLite was chosen as the database to efficiently manage user information, waste transactions, and point balances[13].

A role-based access control model was implemented to distinguish between Admin and Member functionalities. Admin users were given full control over system management, while Members could only access features related to their own transactions and account information.

The system was designed to be scalable, meaning that additional features or modules could be incorporated in the future without major modifications to the core structure. This was achieved by using a modular development approach, where each feature was built independently but integrated seamlessly into the overall system.

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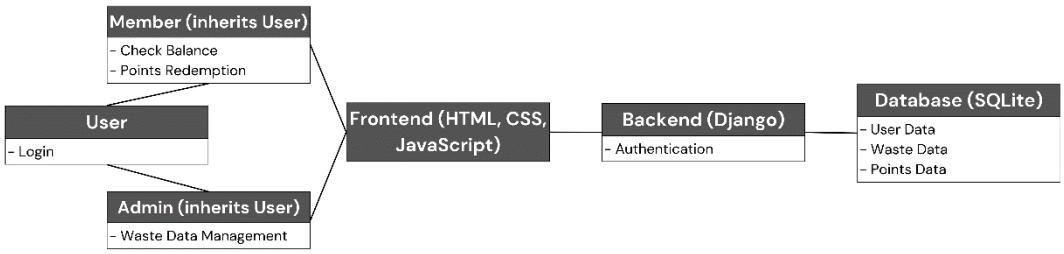

Figure 2. System Architecture Diagram

The system architecture diagram illustrates the flow and interaction between core components of the Tonsea Recycle Center (TRC) Web Application. The Frontend, developed using HTML and CSS, allows users to interact with the platform through interfaces such as login, transaction input, and profile management. These interactions communicate with the Backend, which is powered by the Django framework. Django handles all business logic, user authentication, and request processing. The backend further communicates with the SQLite Database, where essential data such as user records, transaction history, and point balances are securely stored. The diagram also highlights Role-Based Access Control (RBAC)[14], which ensures that Admins and Members can only access features relevant to their role, improving system security and usability.

3.3. Coding Phase

The development of the Tonsea Recycle Center web application was conducted independently, allowing complete control over implementation and ensuring that all functionalities met the predefined system requirements. The coding phase followed an iterative approach, where features were developed incrementally and tested regularly to maintain system stability.

3.3.1. Independent Development

The entire system was built without external collaborators, enabling a streamlined development process with direct decision-making. Each feature was implemented according to the design phase specifications, ensuring alignment with user needs. The choice of Python and Django for backend development provided a structured and efficient coding environment, while HTML, CSS, and JavaScript were used to create a responsive and user-friendly interface[15].

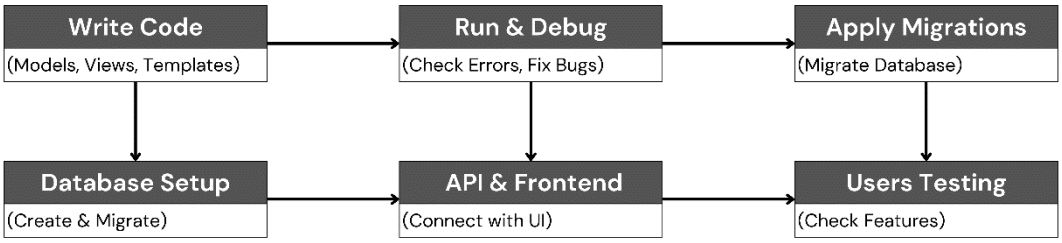

Figure 3. Django Coding and Integration Workflow

3.3.2. Feature Implementations

The feature implementations in this phase were guided by the initial wireframes, which outlined essential components such as the sign-up and login pages, check balance, points redemption, and waste data management. These features were developed to ensure seamless user interaction and functional accuracy. Sign-up and login ensured secure user access, while the check balance feature allowed members to view their current and redeemed points clearly. Points redemption enabled users to request rewards based on their accumulated points, and waste data management allowed admins to monitor and validate each waste transaction efficiently, exporting transaction history to Excel, redesigning the

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point balance section for clearer distinction between total and redeemed points, and enhancing profile management functions for easier user data updates. On the admin side, improvements were made to the user management interface, allowing for smoother editing, and searching.

3.4. Testing Phase

The testing phase ensures that the Tonsea Recycle Center (TRC) web application is functional, secure, and user-friendly. This phase includes two main types of testing: Continuous Testing and User Acceptance Testing (UAT).

3.4.1. Continuous Testing

Continuous testing was performed throughout the development process to identify and fix issues early. Since this project was developed independently, a manual testing approach was used to verify each feature.

Table 2. Manual Testing Results

Test Case	Description	Expected Result	Actual Result	Status
Sign Up	Users register with username, NIK, email, phone number, address, and password.	System successfully creates a new user account.	Works as expected	Passed
Login	Users enter valid credentials to access their account.	System allows access if credentials are correct.	Works as expected	Passed
Check Balance	Users check their accumulated points.	System displays the correct point balance.	Works as expected	Passed
Point Redemption	Users redeem points for available rewards.	System deducts points and updates transactions.	Works as expected	Passed
Waste Data Management	Admin records, updates, and verifies waste transactions.	System saves waste data and updates user points.	Works as expected	Passed
Export Transaction History	Allows users to download their transaction data as Excel	Excel file is successfully generated and downloaded	File downloads with correct format and content	Passed
Clear Point Balance Display	Separates point balance into total, redeemed, and remaining points	Display correctly separates point categories	Displayed correctly as intended	Passed
Edit Profile Info	Users can update phone number and address via profile page	Profile updates are saved and reflected immediately	Profile changes saved successfully	Passed

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Admin Edit User	Admin edits user data in the Manage Users panel	Admin is able to edit and save changes to user info	Edit and save operations completed successfully	Passed
Filter Transaction History	Allows filtering transactions by date and waste type	System filters transactions based on selected criteria	Filter returns accurate results	Passed

3.4.2. User Acceptance Testing (UAT)

After individual features were verified, the system was tested in a real-world environment with actual users. UAT involved key stakeholders, including admins and members, to validate system usability.

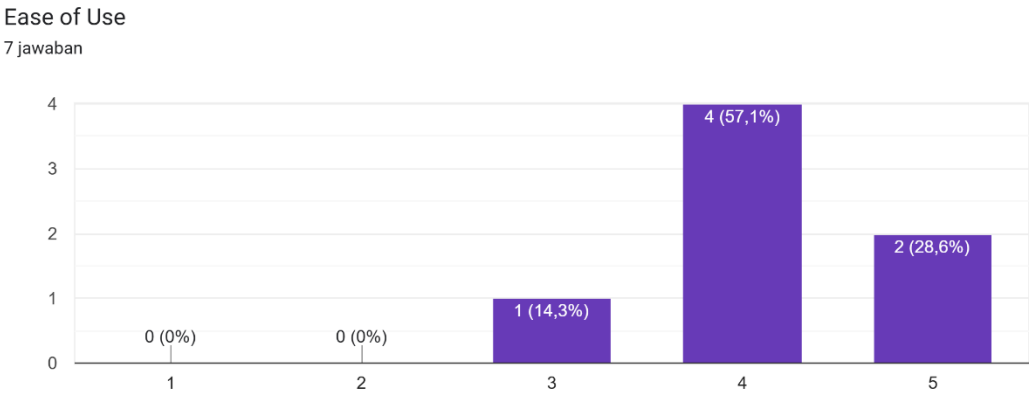

Figure 4. Feedback of Ease of Use

This figure displays user ratings on how easy the system was to navigate. Most users rated the interface as intuitive and user-friendly, which confirms that the design was successful in minimizing learning curves for new users.

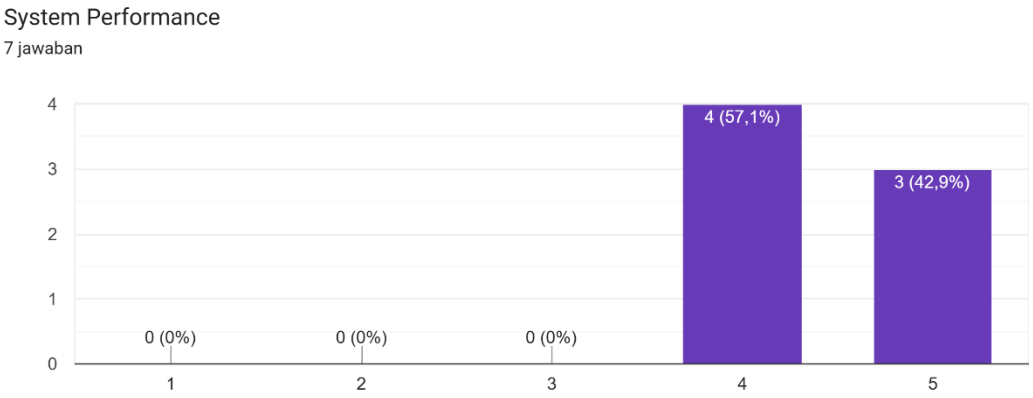

Figure 5. Feedback of System Perfomance

In this figure, users evaluated the responsiveness and speed of the application. The majority of responses indicated that the system performs efficiently, even when handling multiple transactions or switching between features.

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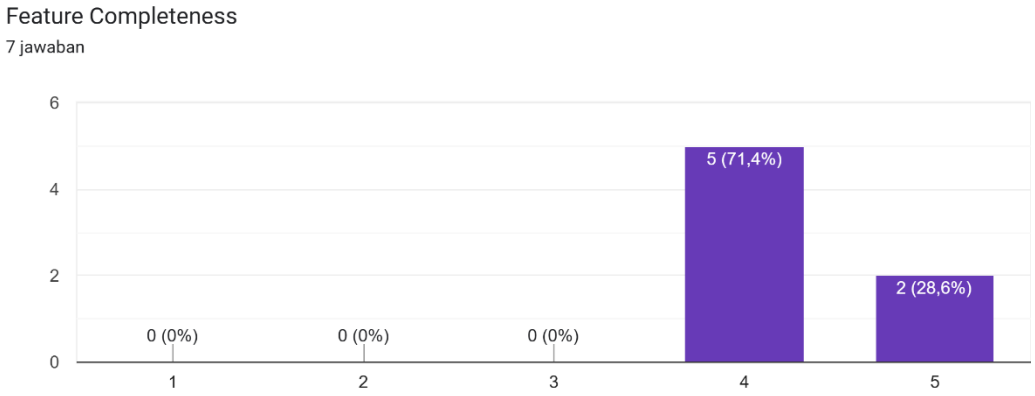

Figure 6. Feedback of Feature Completeness

This figure reflects how well users felt the system covered their needs. Participants were asked to rate the completeness of the features, such as transaction recording, balance checking, and redemption. The feedback shows that the core functionalities addressed most user expectations.

3.5. Deployment Phase

The deployment phase marks the transition from development to real-world use. To ensure a seamless rollout, the system was implemented gradually, starting with a small group of users before expanding to full-scale deployment. This approach allowed for early issue detection and refinement before wider adoption.

3.5.1. Incremental Deployment

The TRC web application was deployed locally for initial use. A pilot deployment was carried out with a small group of users, consisting of TRC administrators and selected members. This group tested core functionalities such as waste transaction input, point checking, and redemption requests. The goal was to validate the functionality in a controlled environment.

Once the pilot phase yielded positive feedback and minor issues were resolved, the system was gradually made accessible to a wider range of users while still hosted on the local server. This incremental approach allowed for smoother adaptation and minimized the risk of widespread system failures.

3.6. Maintenance and Iteration

After deployment, the system entered the maintenance and iteration phase. This stage focuses on ensuring the long-term functionality, reliability, and adaptability of the TRC web application. The system was not considered final upon deployment; instead, it remained open to refinements based on actual usage.

Based on the testing results, all functional modules of the TRC web application operated successfully. The manual testing results show that 10 out of 10 system functions passed the test cases, indicating that the system operates according to the defined requirements. Furthermore, feedback from User Acceptance Testing demonstrates that users perceive the system as intuitive, responsive, and useful for managing waste transactions.

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4. CONCLUSION

The development of the Tonsea Recycle Center (TRC) web application using the Personal Extreme Programming (PXP) method successfully improved waste bank management processes by digitizing transaction records, enabling real-time point tracking, and enhancing operational transparency.

Based on functional testing, all system features successfully passed the testing scenarios, indicating that the application operates according to its design specifications. User Acceptance Testing also demonstrated positive feedback from users regarding system usability, performance, and feature completeness.

However, this study is limited to a web-based implementation and has not yet integrated advanced technologies such as digital payment systems or AI-based waste classification. Future research can focus on expanding the platform into mobile applications and integrating smart waste identification technologies.

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